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# Predicting Timber Sale Costs From Sale Characteristics in the Intermountain West

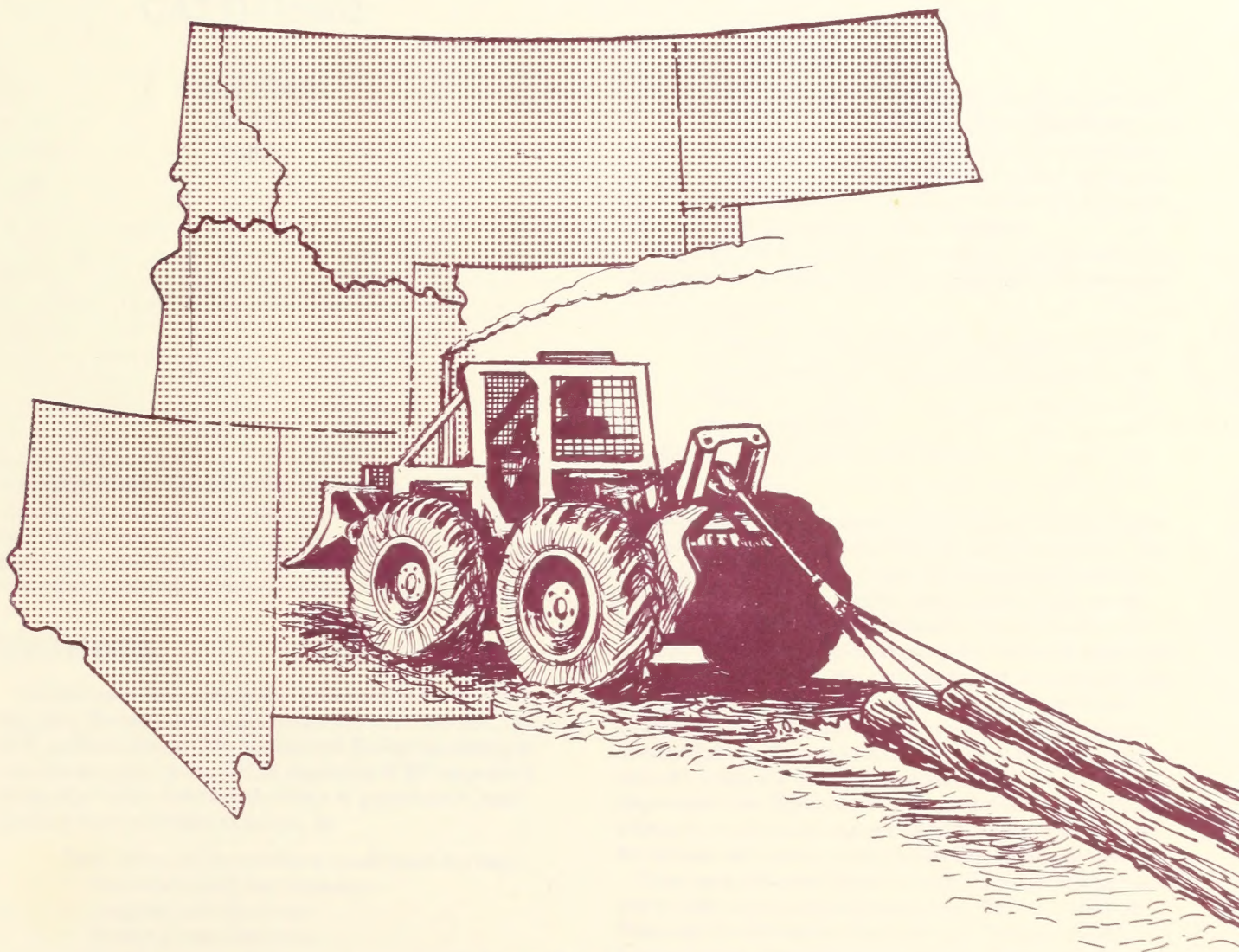
Ervin G. Schuster  
Michael J. Niccolucci

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## THE AUTHORS

**ERVIN G. SCHUSTER** is research forester and Project Leader of the Economics Research Work Unit, Intermountain Research Station, Forestry Sciences Laboratory, Missoula, MT. He received academic training in forestry at the University of Minnesota and Iowa State University, where he received a Ph.D. in forest economics. His research includes modeling timber harvest and timber sale design, and economic impact analysis.

**MICHAEL J. NICCOLUCCI** is an economist with the Economics Research Work Unit. He received academic training in economics at the University of Montana, where he earned his M.A. His research includes timber sale design and appraisal.

## RESEARCH SUMMARY

Information about logging and roading costs can be very important to planning and designing timber sales. Such cost-related information is developed and maintained by the Forest Service, U.S. Department of Agriculture, through a voluminous system of complex handbooks and supplements. This paper presents a much simpler, equation-based method to estimate timber sale costs. We present several statistical models designed to estimate logging and roading cost allowances for timber sales in the Forest Service's Northern and Intermountain Regions. Data were obtained from a sample of timber sales from National Forests between 1983 and 1985. Cost equations follow major appraisal cost categories—slash costs, transportation costs, and so forth. Equations were estimated by a simultaneous equation technique known as Seemingly Unrelated Regression. Equations accounted for 35 percent to 91 percent, averaging 58 percent, of the variation in cost allowances. Use of models to estimate cost changes is illustrated.



# Predicting Timber Sale Costs From Sale Characteristics in the Intermountain West

Ervin G. Schuster  
Michael J. Niccolucci

## INTRODUCTION

Economic analysis of timber sale design often requires estimates of logging and roading costs, or how these costs might change given a proposed sale modification. This cost information is also important when assessing economic efficiency for groups of timber sales and associated road networks, where questions of timing and cost savings are central to the analysis. Timber sale costs are important, because as costs per unit of timber harvested go up, timber value per unit volume goes down.

Logging and roading costs are not directly incurred by the stumpage seller. Neither can they be directly observed. They are borne by and known to the timber purchaser only. The stumpage seller can only surmise what these costs are. In the Forest Service, U.S. Department of Agriculture, special studies are conducted of logging and roading costs. Purchaser records are inspected; time and motion analyses are performed. Findings are presented through a complex system of tables and charts in manuals, handbooks, and supplements. This information is widely used by the Forest Service and other organizations for various purposes, but primarily as the basis for cost allowances when timber stumpage is appraised by the "residual value" method (see Combes 1980).

Unfortunately, this cost information can be very cumbersome or time-consuming to access and can result in far more detailed data than are really necessary. In this paper we present an alternative approach to developing cost allowances. The following presents a set of equations that can be used to easily estimate logging and roading cost allowances. These estimates are suitable for use in economic analyses of individual or groups of timber sales wherever traditional cost allowances are used.

## METHODS

The kinds of timber sale cost information needed to appraise timber (stumpage) value with the residual value (RV) method provide the framework for our modeling of cost allowances. A simplified depiction of RV-appraised stumpage value, treating the costs of permanent (specified) roads as a timber sale cost, is:

$$\begin{aligned} &\text{Total value (of the products made from the logs)} \\ &- \text{Manufacturing cost allowance} \\ &- \text{Logging cost allowance} \\ &- \text{Roading cost allowance} \\ &- \text{Profit and risk allowance} \\ &= \text{Stumpage value (appraised)} \end{aligned}$$

In the case of the Forest Service, agency policy indicates that the appraised stumpage value will be based on an operator of average efficiency (USDA FS 1977). This means that cost allowances, product value specification, and so on are all geared to the "average" operator. But the highest (or winning) bidder may be of above-average efficiency. Depending on a number of factors (USDA FS 1987), the highest bid on the sale may exceed the appraised value by a "bid premium":

$$\begin{aligned} &\text{Stumpage value (appraised)} \\ &- \text{Stumpage value (highest bid)} \\ &= \text{Bid premium} \end{aligned}$$

Conceptually, bid premium can be related to the amount of competition for the sale and/or incorrect specification of total value or cost allowances, all relative to the winning bidder. If cost allowances are excessive compared to the winning bidder's actual costs, bid premium will be larger than when cost allowances are inadequate.

We developed five equations to predict timber sale cost allowances and another equation to predict bid premium:

### Logging costs

Stump-to-truck (fell, buck, skid, load) .....	1
Transportation (haul, road maintenance) .....	2
Slash .....	3
Temporary roads .....	4
Roading costs (permanent roads) .....	5
Bid premium .....	6

Normally, we would use the traditional multiple linear regression to estimate each cost allowance equation. But costs in one phase of the timber sale can affect costs in another phase. For example, the method of felling and bucking can affect the ease of slash removal and/or the need for temporary roads. Hence, the costs and cost equations associated with these processes are not independent of each other. Under this circumstance, conventional estimates of the regression coefficients would be biased and inefficient (Kmenta 1971). This problem was overcome by using the technique of Seemingly Unrelated Regression (see Kmenta 1971), a technique wherein all coefficients in all equations are estimated simultaneously. Statistical tests were conducted at the 10 percent level.

Data were obtained from records of a random sample of 224 timber sales completed between 1983 and 1985 on National Forests in the Northern and Intermountain Regions of the Forest Service (fig. 1). These were large-volume sales, each containing 2 million bd ft or more.



Information about each sale was found in official sale records, such as the timber sale report and appraisal summary.

Cost allowances and bid premiums were used as dependent variables, both expressed in dollars per thousand board feet (M bd ft) of timber harvest. Detailed cost information, such as allowances for felling and bucking costs, slash disposal costs, and so on, was obtained directly from the timber sale appraisal summary (Forest Service Form 2400-17). Similarly, information from sale summary was used to calculate bid premium as the difference between advertised rate and high bid. All dollar information was expressed in 1985 dollars, using the GNP Implicit Price Deflator (BOC 1987).

Sale characteristics were used as the independent variables. Various timber sale records provided information on 40 sale characteristics, including sale *features* such as volume harvested and miles of road construction and sale *requirements* such as dust control and haul restrictions. Sale features were measured as continuous variables. Sale requirements were binary, measured as 0 or 1, present or absent.

Cost allowance equations were estimated in four steps. First, linear correlation analysis eliminated all but the 26 most promising or useful sale characteristics. Subsets from these 26 characteristics were used as potential independent variables to estimate each cost equation. Second, traditional multiple linear regression analysis was next used to identify the best subset of the 26 potential variables for each cost allowance model (see Draper and Smith 1981 on adjusted  $R^2$  and Mallows's  $C_p$ ). Third, using those variables, cost equations were reestimated with the Seemingly Unrelated Regression routine of SORITEC software (Sneed and others 1986). Finally, equations were tested for compliance with underlying statistical assumptions (see Weisberg 1980 on Box-Tidwell analysis) and two transformations adjusted for

nonlinear relationships: the reciprocal transformation ( $Y = 1/X$ ) and the square root transformation ( $Y = X^{1/2}$ ). If any of the previously identified variables became non-significant in the reestimated equations, they were discarded and the equation again reestimated. Ultimately, 19 sale characteristics were used as independent variables; the rest were dropped from further consideration.

Although bid premium depends on both market circumstances and errors in cost allowances, we were interested only in the cost allowance portion. It is quite difficult, however, to ascertain how much of the bid premium is due to cost allowance errors and how much to the effect of market circumstances. Our approach was therefore restrained, purposefully limiting the portion of bid premium ascribed to errors in cost allowance. The bid premium equation was estimated with traditional multiple linear regression through a three-step process. In the first step, bid premium was modeled as a function of market-related variables only—number of bidders and the selling price of lumber. This effectively ascribed the maximum amount of bid premium to market circumstances. In the second step, the five cost categories were added as independent variables to that model, and the model reestimated. Statistically nonsignificant cost categories were discarded, and the model was again reestimated in the third step. Coefficients on cost category variables depict the influence of cost allowance errors on bid premium.

## RESULTS

In total, 12 equations were estimated—six (the five cost categories plus the bid premium equation) for the Northern Region and six for the Intermountain Region. The listing below shows that allowances for stump-to-truck costs were most important, accounting for more than half of the \$153/M bd ft overall averages in allowances:

### Northern and Intermountain Regions average allowance 1985 \$/M bd ft

Stump to truck	\$82.15
Transportation	38.54
Slash	13.59
Specified roads	18.13
Temporary roads	.97
	<hr/>
	\$153.38
Bid premium	–26.39
	<hr/>
	\$126.99

These cost allowances combine with overbids to account for total adjustments. The variation in the cost allowances explained by the equations ranged from 35 percent to 91 percent, averaging 58 percent. Equations for the Intermountain Region were above the average, the Northern Region below.

The 19 variables used in final models are defined in table 1. All but one described sale characteristics; the sole sale requirement variable concerned dust control. As

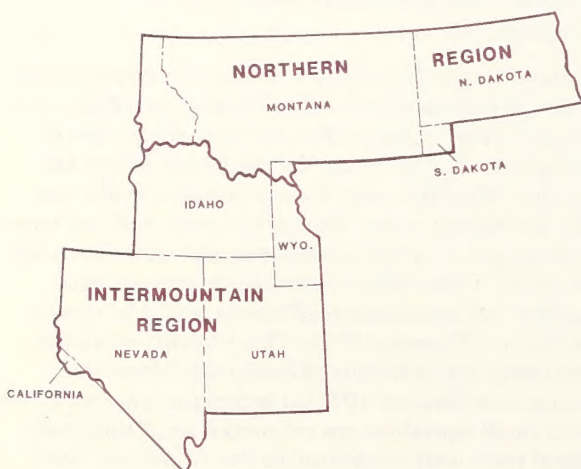


Figure 1—The Northern Region and Intermountain Region of the Forest Service.



indicated before, measurements on these variables for each sale were made from sale records. For example, required corridor spacing (SPACE), measured in feet, is specified in both the contractual clauses of the sale contract and the timber sale report.

Not to be confused with total costs, the following equations express costs in thousand board feet of timber harvested, a type of average cost. All values are expressed in 1985 dollars.

## Stump to Truck

Stump-to-truck costs include costs associated with felling and bucking trees as well as skidding trees to the landing and loading. These costs were the largest, accounting for over half of the allowances modeled. Stump-to-truck cost allowances averaged \$85.02/M bd ft in the Northern Region and \$76.82 in the Intermountain Region.

Table 2 shows the final cost estimation models for the Regions studied along with the percentage of variation in

**Table 1**—Independent variables used in study

Variable	Description	Units
<b>Sale Characteristics</b>		
SPLT	Selling price, lumber tally	\$ per M bd ft (Scribner)
VOL	Total sale volume harvested	M bd ft (Scribner)
VPA	Volume per acre harvested	M bd ft (Scribner)
ACRES	Acres harvested in sale	Acres
%TRA	Percent volume tractor yarded	Percent
SPACE	Corridor spacing	Feet
%GSL	Percent volume group selection	Percent
%CC	Percent volume clearcut, seedtree, or right-of-way	Percent
STEEP	Sale area > 55 percent slope	Acres
FLAT	Sale area 0-35 percent slope	Acres
#UNIT	Number of cutting units	Number
YT	Average maximum tractor yarding	Feet
UHAUL	Unpaved haul distance	Miles
PHAUL	Paved haul distance	Miles
ADBH	Average tree diameter	Inches
TEMP	Temporary road construction	Miles
NEW	New road construction	Miles
RECON	Old road reconstruction	Miles
<b>Sale Requirements</b>		
DUSTR	Dust control restrictions	1 = Yes 0 = No

**Table 2**—Stump-to-truck cost estimation equations<sup>1</sup>

Variable	Northern Region		Intermountain Region	
	Coefficient	Standard error	Coefficient	Standard error
Constant	26.32	5.60	112.14	17.64
%TRA	-.33	.05	-1.00	.11
VPA <sup>1/2</sup>			-6.35	2.53
1/VPA	140.40	40.17		
#UNITS			.28	.12
YT			.03	.01
1/ADBH	760.00	83.82	871.49	119.41
FLAT <sup>1/2</sup>			-.70	.24
SPACE			-.08	.03
STEEP	.10	.02		
%GSL	.48	.11		
ACRES <sup>2</sup>	1.32x10 <sup>-5</sup>	.44x10 <sup>-5</sup>		
R <sup>2</sup>		.68		.65

<sup>1</sup>See table 7 for possible adjustment.



stump-to-truck costs explained by the models (labeled " $R^2$ "). Both models performed exceedingly well. The model developed for the Northern Region explained 68 percent of the variation in stump-to-truck costs. The Intermountain Region model explained 65 percent of the variation. Tree size (ADBH) and the amount of steep land (STEEP) were the most important variables explaining stump-to-truck costs in the Northern Region. Percent of the volume tractor yarded (%TRA) and ADBH were most important in the Intermountain Region.

In effect, the equations portray stump-to-truck costs as a function of terrain, slope, and tree size. STEEP and the amount of flat land (FLAT) obviously relate to slope. But so does %TRA, because tractor operations typically take place on flatter lands. Steepness is costly, shown by the positive sign on the coefficients. As the percentage of the timber sale tractor yarded goes down or steep land goes up, stump-to-truck costs go up. The ADBH variable indicates that regardless of slope, it is less costly (per thousand board feet) to log larger trees.

## Transportation

Transportation costs could also be called log haul costs. The term refers to the costs of moving logs from the timber sale to the initial milling site—haul costs and road maintenance costs. These costs averaged \$36.10/M bd ft in the Northern Region and \$42.99 in the Intermountain Region.

Cost estimation models developed for transportation costs explained the most variation of any cost model developed. The equation shown in table 3 for the Northern Region accounts for 76 percent of the variation, while the Intermountain Region model accounts for 91 percent. In both Regions, miles of unpaved haul road (UHAUL) was the single most important variable, accounting for about half of the variation explained. Along with unpaved haul, paved haul (PHAUL) and log size (ADBH) were consistently important, in that order.

The cost equations explain transportation costs by distance traveled. For both Regions, the distance of unpaved and paved haul are significant variables. Together, they sum to total haul distance. These variables always have positive coefficients, meaning that as distance increases so do transportation costs. The size of the coefficients suggests that each mile of unpaved haul is about twice as costly as paved haul. The ADBH variable shows that, regardless of distance, it is less costly (per thousand board feet) to haul large logs than small ones. Apparently, this reflects the notion that smaller logs have less board-foot volume per unit of log weight than larger logs. Because dust control restrictions (DUSTR) is a binary (0/1) variable, transportation costs in the Northern Region increase by \$4.92/M bd ft when it is present.

## Slash

Slash disposal costs refer to costs of cleaning up logging debris to prepare the site for regeneration activities. Slash disposal costs averaged \$14.44/M bd ft in the Northern Region and \$12.00 in the Intermountain Region.

The relatively low  $R^2$ 's shown in table 4 for the slash cost models suggest that slash cost allowances were more variable than other costs discussed. Only about half of the variation in slash costs allowances was explained by these models. Moreover, the importance of variables differed widely between Regions. Corridor spacing (SPACE) was the single most important explanatory variable in the Northern Region, while volume per acre (VPA) was most important in the Intermountain Region. VPA and the number of cutting units (#UNITS) were second important in the Northern Region and percent of the area clearcut (%CC) was second in the Intermountain Region.

The cost equations portray slash costs in terms of ease and efficiency of operation. Narrower corridor spacing, flatter ground, and either more group selection or less clearcut all make for easier operations and lower unit costs. Similarly, greater volumes per acre and fewer cutting units both promote efficiency, and hence cost economies of scale in slash removal operations. But so does removing slash from larger diameter trees, because sites with these trees will carry a disproportionately large volume per unit of land.

## Permanent Roads

In the Forest Service, these permanent roads are called "specified" roads. They are major roads that access the timber sale and will remain after the sale is completed. These roads can become part of an official, numbered road network for a National Forest. The average cost of permanent roads was \$19.62/M bd ft in the Northern Region and \$15.93/M bd ft in the Intermountain Region.

The cost estimation models developed for permanent roads explained about 35 and 55 percent of the variation in costs in the Northern Region and Intermountain Region, respectively. Table 5 shows these models. The miles of new roads to be constructed (NEW) was clearly the most important variable in explaining permanent road costs. It alone accounted for about half of the variation explained. Note that total road construction is simply the sum of new road miles and reconstructed road miles.

Cost equations for permanent roads show that miles of road constructed are useful in predicting road costs per thousand board feet. Assume that in addition to fixed costs, the cost per mile of road constructed is constant. The road coefficients identified in this study then imply that the amount of timber accessed by new roads increases faster than do the miles of access roads, on a percentage basis. For under these circumstances, permanent road costs, expressed in terms of a unit of timber harvest, increase as a decreasing function of miles of access roads.



**Table 3**—Transportation cost estimation equations<sup>1</sup>

Variable	Northern Region		Intermountain Region	
	Coefficient	Standard error	Coefficient	Standard error
Constant	-7.96	3.75	-8.93	2.42
1/ADBH	225.61	35.04	322.43	28.56
UHAUL	.98	.05	1.01	.04
PHAUL	.44	.05	.50	.03
DUSTR	4.92	1.65		
$R^2$		.76		.91

<sup>1</sup>See table 7 for possible adjustment.**Table 4**—Slash cost estimation equations

Variable	Northern Region		Intermountain Region	
	Coefficient	Standard error	Coefficient	Standard error
Constant	11.59	2.83	4.53	3.52
SPACE	.05	.01	.02	.01
VPA			-.48	.11
1/VPA	77.47	16.38		
ADBH	-.48	.16		
1/ADBH			149.80	41.31
FLAT	-.01	0	-.002	.001
%CC			.04	.02
%GSL	-.11	.05		
#UNITS	.27	.06		
$R^2$		.42		.50

**Table 5**—Permanent road cost estimation equations

Variable	Northern Region		Intermountain Region	
	Coefficient	Standard error	Coefficient	Standard error
Constant	2.84	2.13	-9.72	3.20
STEEP			.03	.01
NEW <sup>1/2</sup>	8.12	1.05	9.20	1.15
RECON <sup>1/2</sup>	2.93	1.10	4.10	1.09
1/VOL			31,321.00	8,516.00
$R^2$		.35		.55



## Temporary Roads

Unlike permanent roads that remain after the timber sale is finished, temporary roads return to nature. Road access is blocked, the roadbed is planted to grass, and so on. Temporary roads are typically minor facilities within the timber sale and are relatively inexpensive. The average cost of temporary roads in the Northern Region was \$0.85/M bd ft and \$1.19/M bd ft in the Intermountain Region.

Table 6 presents the models developed for temporary road costs. As shown by the  $R^2$ 's, these models explain about the same amount of variation in costs as previously shown for permanent roads. And again, the model for the Intermountain Region explained more variation in temporary road costs than did the Northern Region's model—56 percent vs. 38 percent. In both Regions, the miles of temporary roads (TEMP) was by far the most significant explanatory variable. In the Northern Region, sale size (ACRES) was next most important, while in the Intermountain Region, total sale volume (VOL) was second.

Temporary road costs (per thousand board feet) are best predicted from knowledge of road miles. Given the sizes of the timber sales studied, temporary road costs per unit of timber harvested increase as a function of miles of roads. Stated differently, timber sales with more miles of temporary road do not have correspondingly more volumes harvested. The sale size variable (in acres) in the Northern Region and the sale volume variable (in million board feet) in the Intermountain Region both represent sale size, and both reflect cost economies of scale.

## Bid Premium

To this point our cost estimation models merely predict cost allowances developed by Forest Service personnel when appraising timber under the residual value method. Nobody really knows if these cost allowances are correct. Similarly, nobody really knows if the product values described in the appraisal are correct. If cost allowances are too high and/or value allowances too low, the winning stumpage bid may well exceed the appraised value, especially if several bidders are competing for the sale. This differential is "bid premium," sometimes called "overbid." Bid premium averaged about \$36.16/M bd ft in the Northern Region and \$8.60/M bd ft in the Intermountain Region.

Table 7 shows the models developed to estimate bid premium. As stated earlier, these models attempt to account for errors in product value (through SPLT), bidder competition for the sale (through #BIDDERS) and errors in cost allowances (through five cost categories). Final models explained about 55 percent of the variation in bid premium in the Northern Region and only 19 percent in the Intermountain Region. The amount of variation explained by the Intermountain Region model is surprisingly low, indicating that our simple model is not adequate to explain bid premium. Perhaps unmodeled factors, such as those related to purchaser expectations and speculation, play a more dominant role in the Intermountain Region than in the Northern Region.

**Table 6**—Temporary road cost estimation equations

Variable	Northern Region		Intermountain Region	
	Coefficient	Standard error	Coefficient	Standard error
Constant	0.63	0.17	2.82	0.51
TEMP	.56	.06		
TEMP <sup>1/2</sup>			1.65	.19
VOL <sup>1/2</sup>			-.04	.01
ACRES	-.0004	0		
$R^2$	.38		.56	

**Table 7**—Bid premium cost estimation equations

Variable	Northern Region		Intermountain Region	
	Coefficient	Standard error	Coefficient	Standard error
Constant	-17.85	9.55	-16.09	9.60
#BIDDERS	9.91	1.02	5.61	2.04
SPLT	.16	.02	.06	.03
Stump-to-truck	-.14	.08	-.11	.06
Transportation	ns <sup>1</sup>	ns	.18	.11
Slash	ns	ns	ns	ns
Permanent road	ns	ns	ns	ns
Temporary road	ns	ns	ns	ns
$R^2$	.55		.19	

<sup>1</sup>ns = nonsignificant.



Statistically significant coefficients for cost categories mean that bid premium is systematically related to cost allowances. A negative coefficient means that bid premium is lowered because of this variable, implying that the appraisal's cost allowance was too small. When this situation occurs, cost estimates from previous equations should be increased. A positive sign means the cost allowance was too large; previous cost estimates should be decreased. Because cost category variables were measured in dollars per thousand board feet, coefficients are interpreted as a percentage adjustment.

Most of the variation in bid premium explained by our models used variables reflecting competition and product value—#BIDDERS and SPLT—not cost allowance variables. In fact, the #BIDDERS alone explained 53 percent (out of 55 percent) of the variation in bid premium in the Northern Region and 13 percent (out of 19 percent) in the Intermountain Region.

We therefore conclude that the cost allowance estimation equations previously shown are mostly adequate, as is, with three exceptions. In the Northern Region, the  $-0.14$  coefficient on stump-to-truck cost estimates is statistically significant, implying that these cost estimates are about 14 percent too low. Similarly, significant coefficients for the Intermountain Region imply that stump-to-truck cost allowances there are about 11 percent too low while transportation cost allowances are 18 percent too high. Under these circumstances, estimated cost allowances should be adjusted if a better approximation of actual costs is desired. For example, an estimated transportation cost allowance of \$50/M bd ft for the Intermountain Region should be decreased by 18 percent to \$41 if an estimate of actual transportation cost is desired.

## DISCUSSION

How well do the equations presented here actually model logging and roading costs, and for how long? We do not and cannot know how well our models of appraisal allowances estimate actual costs, because actual cost information is proprietary—known only to the logging operators. The only question to which we can respond is one of how well our cost allowance equations predict actual cost allowances. We think they perform quite well, explaining up to 91 percent of the variation in line item cost allowances. But technological change will cause our models to become out of date in the same way as the cost allowance manuals become out of date. We do not know when this will happen.

Figure 2 provides another perspective on how well our predicted cost allowances match actual allowances. The histograms show the percentage of predicted allowances within \$10/M bd ft of the actual, within \$10 to \$20 of the actual, and within \$20 to \$30 of the actual. For example, 63 percent of the predicted transportation cost allowances (from our models) were within 10 percent of the actual allowance in the Northern Region; 76 percent of the predictions were within 10 percent of the actuals in the Intermountain Region. Because the average transportation cost allowance in the Intermountain Region was \$42.99/M bd ft, that means more than three-fourths of the estimated transportation allowances were within \$4.30 of the

actual allowance. Overall, 78 percent of all estimates were within 30 percent of the means in the Northern Region; 71 percent were within 30 percent in the Intermountain Region.

We conclude with an illustration in which we estimate a transportation cost allowance for a hypothetical timber sale from the Intermountain Region (TCA)<sup>IR</sup>. For simplicity, assume this sale can be depicted as the mean value for each sale characteristic found important in this study. Those means are displayed in table 8. Table 3 earlier showed that transportation costs could be modeled as:

$$(TCA)^{IR} = -8.93 + 322.43(1/ADBH) + 1.01(UHAUL) + 0.50(PHAUL)$$

Table 8 shows the average diameter of the trees harvested (ADBH = 13.99 inches), along with the average miles of paved and unpaved roads. Using these averages, the allowance is calculated:

$$\begin{aligned}(TCA)^{IR} &= -8.93 + 322.43(1/13.99) + 1.01(12.27) \\ &\quad + 0.50(26.56) \\ &= -8.93 + 2.41 + 12.39 + 13.28 \\ &= \$39.79/\text{M bd ft}\end{aligned}$$

This is only about 7 percent off the actual average transportation allowance, \$42.99/M bd ft.

The question of bid premium must also be considered. However, adjustments reflecting the effect of errors in cost allowances on bid premium should not always be made. We recommend that if the appraisal's objective is to estimate or approximate Forest Service cost allowances, no adjustment should be made. But if the objective is to estimate actual logging and roading costs (or to estimate stumpage value where cost allowances are not combined with an independent estimate of bid premium), apply the cost allowance adjustments shown in table 7. Finally, if the objective is to estimate stumpage value where cost allowances are combined with an independent estimate of bid premium, cost allowances should not be adjusted; this will preclude the possibility of double counting the effect of bid premium.

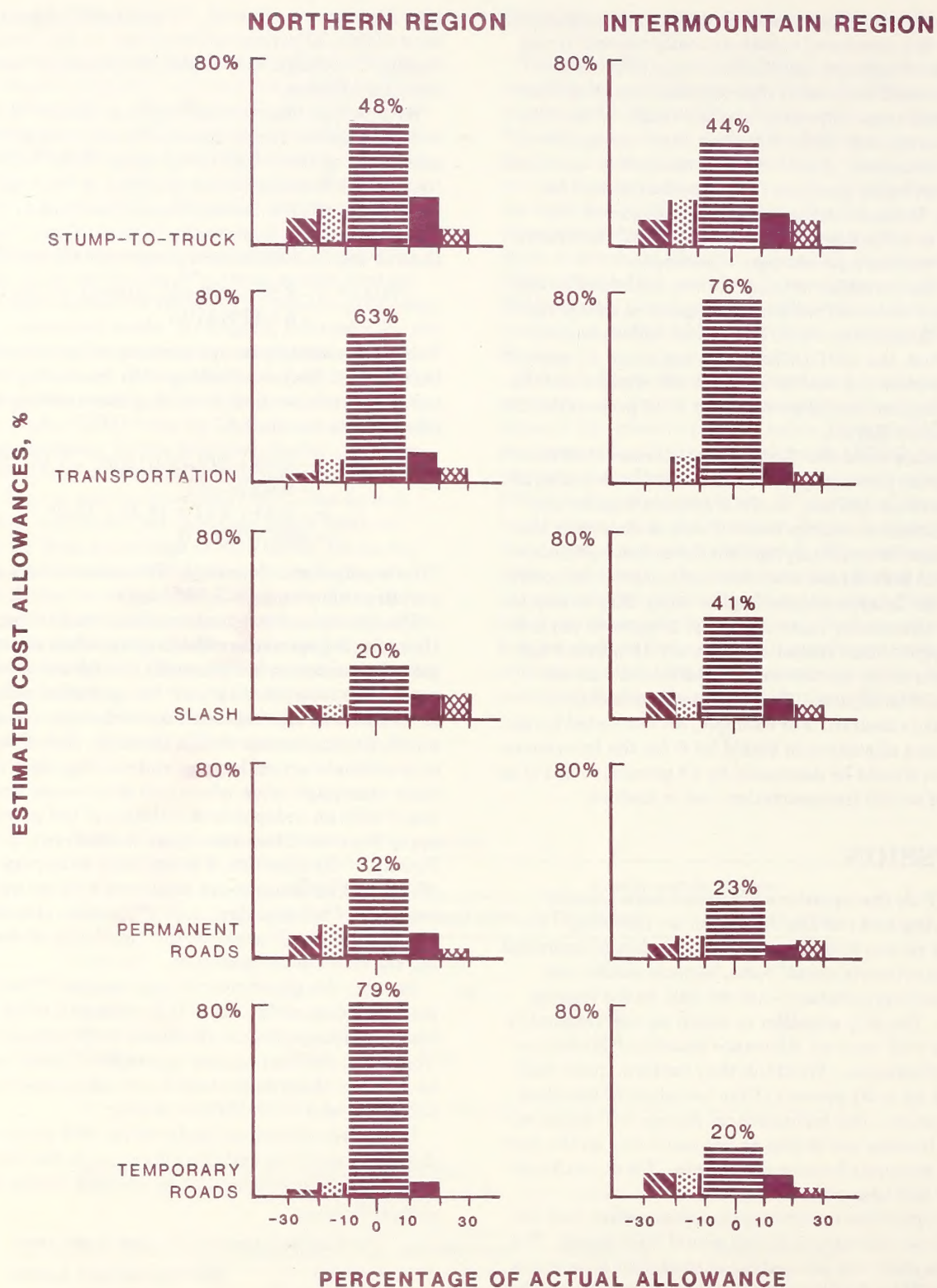
Assume the adjustment is appropriate. Then the transportation cost coefficient of 0.18 shown in table 7 means that the transportation allowance is 18 percent too high. Therefore, a more accurate portrayal of these costs would be to lower the transportation cost allowance to \$32.63/M bd ft ( $= 39.79(1.0 - 0.18)$ ).

If the cost allowance displayed in 1985 dollars is not desired, simply convert the allowance to the desired base year. The following tabulation shows a listing of conversion factors:

Factors to convert to new base year	
Year	Multiplication factor
1980	0.7707
1981	.8453
1982	.8993
1983	.9344
1984	.9721
1985	1.0000
1986	1.0261
1987	1.0567

Source: Adapted from BOC 1987 and BEA 1988.





**Figure 2**—Closeness of cost allowance predictions to cost allowance, by cost category, for Northern Region and Intermountain Region.



**Table 8**—Means of independent variables used in study

Variable	Units	Northern Region	Intermountain Region
<b>Sale Characteristics</b>			
SPLT	\$ per M bd ft	220.05	235.45
VOL	M bd ft	8,243.63	8,220.35
VPA	M bd ft	20.37	10.28
ACRES	Acres	404.77	800.03
%TRA	Percent	56.93	86.69
SPACE	Feet	56.64	56.32
%GSL	Percent	2.80	4.03
%CC	Percent	69.70	46.31
STEEP	Acres	47.50	50.40
FLAT	Acres	236.33	582.83
#UNITS	Number	17.35	21.80
YT	Feet	672.26	659.29
UHAUL	Miles	13.93	12.27
PHAUL	Miles	20.59	26.56
ADBH	Inches	13.66	13.99
TEMP	Miles	1.06	1.44
NEW	Miles	3.54	2.56
RECON	Miles	1.87	1.92
<b>Sale Requirements</b>			
DUSTR	1 = Yes 0 = No	0.79	0.82

These factors can be applied to any dollar-based number presented in this paper, including means, coefficients, or results such as the \$32.63/M bd ft transportation cost estimate just calculated. Assume this value is desired in 1987 dollars. Simply locate the conversion factor for 1987 shown in the above tabulation (i.e., 1.0567). The converted value (\$34.48) is determined by multiplying the value in question by the conversion factor ( $= 32.63 \times 1.0567$ ).

Finally, as with all research, results presented in this paper should not be applied to situations differing appreciably from those contained in the timber sales studied. The set of means shown in table 8 shows the magnitude of many sale characteristics. More importantly, sales sampled included only sales of 2 million bd ft or more. Therefore, study results should not be applied to smaller volume sales. Within these limitations, equations presented for cost allowances can serve many uses, especially in analyses related to timber sale planning and design.

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Presents a simple, equation-based method to estimate timber sale costs. Data were obtained from timber sales on National Forests in the Intermountain West. Equations were estimated by Seemingly Unrelated Regression.

**KEYWORDS:** timber management, logging costs, stumpage value, timber sales

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